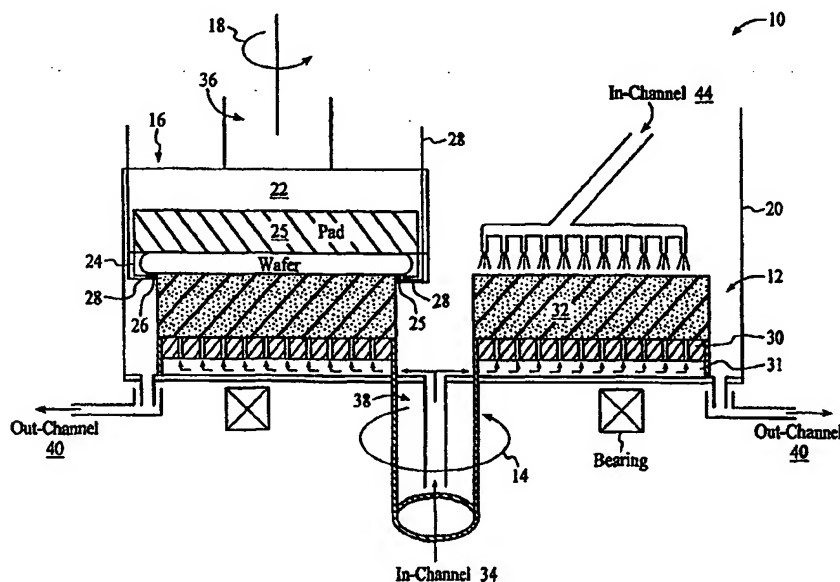




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : C25D	A2	(11) International Publication Number: WO 00/26443 (43) International Publication Date: 11 May 2000 (11.05.00)
(21) International Application Number: PCT/US99/25656 (22) International Filing Date: 2 November 1999 (02.11.99) (30) Priority Data: 60/106,853 3 November 1998 (03.11.98) US 09/201,929 1 December 1998 (01.12.98) US (71) Applicant: NUTOOL, INC. [US/US]; 1645 McCandless Drive, Milpitas, CA 95035 (US). (72) Inventor: TALIEH, Homayoun; 2211 Bentley Ridge Drive, San Jose, CA 95138 (US). (74) Agents: JAKOPIN, David, A. et al.; Pillsbury Madison & Sutro LLP, 1100 New York Avenue N.W., Washington, DC 20005 (US).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>Without international search report and to be republished upon receipt of that report.</i>

(54) Title: METHOD AND APPARATUS FOR ELECTROCHEMICAL MECHANICAL DEPOSITION

**(57) Abstract**

The present invention deposits a conductive material from an electrolyte solution to a predetermined area of a wafer. The steps that are used when making this application include applying the conductive material to the predetermined area of the wafer using an electrolyte solution disposed on a surface of the wafer, when the wafer is disposed between a cathode and an anode, and preventing accumulation of the conductive material to areas other than the predetermined area by mechanically polishing the other areas while the conductive material is being applied.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon	KR	Republic of Korea	PL	Poland		
CN	China	KZ	Kazakhstan	PT	Portugal		
CU	Cuba	LC	Saint Lucia	RO	Romania		
CZ	Czech Republic	LI	Liechtenstein	RU	Russian Federation		
DE	Germany	LK	Sri Lanka	SD	Sudan		
DK	Denmark	LR	Liberia	SE	Sweden		
EE	Estonia			SG	Singapore		

METHOD AND APPARATUS FOR ELECTROCHEMICAL MECHANICAL DEPOSITION

Background of the Invention

5 Field of the Invention

The present invention relates to a Method and Apparatus for Electrochemical Mechanical Deposition, and more particularly, to a method and apparatus that provides for both the deposition and polishing of a conductive material on a semiconductor wafer.

Background of the Invention

10 Metallization of semiconductor wafers, i.e. deposition of a layer of metal on the face of wafers over a barrier/seed layer of metal has important and broad application in the semiconductor industry. Conventionally, aluminum and other metals are deposited as one of many metal layers that make up a semiconductor chip. More recently, there is great interest in the deposition of copper for interconnects on semiconductor chips, since, as compared to aluminum, copper reduces electrical resistance and
15 allows semiconductor chips using copper to run faster with less heat generation, resulting in a significant gain in chip capacity and efficiency.

Conformal thin film deposition of copper into deep submicron via holes and trenches is becoming more difficult in ULSI chip processing, especially when the feature sizes are decreasing below the 0.25 μm with aspect ratios of greater than 5 to 1. Common chemical vapor deposition and electroplating
20 techniques have been used to fill these deep cavities etched into silicon substrates. These processes so far have yielded a very high cost and defect density for developing and integrating local interconnects for ULSI technology.

One of the factors that contributes to the high cost is the manner in which the conductive material, and particularly copper, is applied. Specifically, it is well known to apply certain contaminants, known
25 as leveling agents, in the electrolyte solution that prevent or slow down the rate of deposition of the metal to the surface of the wafer substrate. Since these contaminants have a large size in comparison to the size of the typical via that needs to be filled, deposition of the metal on the surface of the wafer is, in part, prevented. This prevention, however, is achieved at the expense of adding contaminants to the electrolytic solution, which results, in part, in vias that do not have the desired conductive character-
30 istics. In particular, the grain size of the deposited conductor, due to the use of such contaminants, is not as large as desired, which thereby results in quality problems for the resulting device, as well as increased expense due to significant annealing times that are subsequently required.

Further, the cost of achieving the desired structure, in which the conductive material exists in the via but not on the substrate surface, still requires separate deposition and polishing steps. After the
35 conventional deposition of the metal using an anode, cathode and electrolytic solution containing metal as is known, there is then required a polishing step, which polishing step is, for high performance devices at the present time, typically a chemical-mechanical polishing step. While chemical mechanical

polishing achieves the desired result, it achieves it at considerable expense, and requires a great degree of precision in applying a slurry in order to achieve the desired high degree of polish on the conductive surface.

Accordingly, a less expensive and more accurate manner of applying a conductor to a semiconductor wafer is needed.

Summary of The Invention

It is an object of the present invention to provide a method and apparatus that both deposits and polishes a conductive material on a semiconductor wafer.

It is an object of the invention to provide a method and apparatus that simultaneously deposits and polishes a conductive material on a semiconductor wafer.

It is an object of the invention to provide a method and apparatus that simultaneously deposits a conductive material in deep cavities of a semiconductor wafer and polishes/starves electrolytic solution from the top surface area of the semiconductor wafer.

It is a further object of the invention to provide a method and apparatus that recirculates the electrolytic solution used in depositing the conductive material on the semiconductor wafer.

These and other objects of the invention are obtained by depositing a conductive material from an electrolyte solution to a predetermined area of a wafer. The steps that are used when making this application include applying the conductive material to the predetermined area of the wafer using an electrolyte solution disposed on a surface of the wafer, when the wafer is disposed in proximity to an anode, and preventing accumulation of the conductive material to areas other than the predetermined area by mechanically polishing, protecting, or reducing from electrolyte contact to the other areas while the conductive material is being deposited.

An apparatus that performs this method includes an anode capable of receiving a first potential upon application of power. A cathode or the wafer is spaced from the anode and is capable of receiving a second potential opposite the first potential upon application of power. A pad or a multiple number of pads is/are disposed between the anode and the cathode, the pad being movable with respect to a surface of the wafer and inhibiting or reducing application of the conductive material to certain other areas when power is being supplied to the anode and the cathode. Further, a fluid chamber allows an electrolyte solution to be disposed on the surface of the wafer or the pad and the conductive material to be formed on desired areas of the wafer upon application of power.

Brief Description of the Drawings

These and other objects and advantages of the invention will become apparent and more readily appreciated from the following detailed description of the presently preferred exemplary embodiment of the invention taken in conjunction with the accompanying drawings, of which:

Figs. 1A and 1B illustrate a first embodiment of the invention;

Fig. 2 illustrates a second embodiment of the invention;

Fig. 3 illustrates a representative via to be filled with a conductor according to the invention; and

Figs. 4A - 4C illustrate a third embodiment of the invention.

5

Detailed Description of the Preferred Embodiments

The preferred embodiments of this invention will now be described. As noted above, conventional processing uses different equipment, at different times, in order to obtain conductive material within vias or at other desired locations on the surface of a semiconductor wafer that contains many different semiconductor chips, but not have the conductive material disposed at undesired locations. Accordingly, the equipment cost needed to manufacture a high quality semiconductor integrated circuit device can be exorbitant.

The present invention contemplates different embodiments which allow for the same device, termed a "electrochemical mechanical deposition apparatus", to be used to both deposit a conductive material, as well as then polish or reduce the rate of deposition of that conductive material. The "electrochemical mechanical deposition apparatus" can also be used to simultaneously deposit and/or polish the conductive material. While the present invention can be used with any conductive material or any workpiece suitable for plating, it is especially suited for use with copper as the conductor, and for use in the fabrication of ULSI integrated circuits having submicron features with large aspect ratios. In the various embodiments, the present invention uses conventional components, arranged in a unique manner, in order to achieve the functionalities described herein.

Figure 3 is first referred to in order to illustrate a portion of an integrated circuit chip that includes an area in which a via is to be formed. The via, as known in the semiconductor arts, being a conductive material that electrically connects different circuit layers together. As shown in Fig. 3, a via contains a conductor 2 that can connect a lower level conductive area 4 with an upper level conductive area 6, with insulative material 8 disposed therearound. Of course, it is understood that the present invention can operate upon any metal layer of a multi-layer integrated circuit chip.

Figs. 1A and 1B illustrate a first embodiment of the invention, which embodiment has two different modes of operation. In a first mode, a conductive metal, preferably copper, or other conductive material, is applied in vias and/or other desired areas using an electrolyte solution, while build-up of the conductive material on undesired areas is eliminated, or at least minimized, due to the mechanical polishing and/or electrolytic solution deprivation to top surface areas of the semiconductor wafer that is described hereinafter. In a second mode of operation, polishing of the wafer, using a conventional chemical mechanical polishing, can be performed using the same device, to the extent that such chemical mechanical polishing is needed. It is contemplated that, according to this embodiment of the invention, in most circumstances only the first mode of operation will be needed. The second mode of

operation and the structure corresponding thereto are included for circumstances in which an extremely high degree of polish is desired.

Fig. 1A illustrates an overview of the electrochemical mechanical deposition apparatus 10 according to the first embodiment of the invention, illustrating in perspective view the mechanical pad assembly 12 that has a mechanical pad 32 that rotates around a first axis 14, and a wafer head assembly 16 that has a wafer that rotates around a second axis 18. As illustrated, the wafer rotates within an area that is covered by the mechanical pad 32, as will be described in further detail hereinafter, which area is within container 20 that keeps various solutions disposed therein. Although shown as operating upon a single wafer, it is understood that a plurality of wafer head assemblies 16 could be associated with each mechanical pad assembly 12, and that the apparatus 10 could include a plurality of mechanical pad assemblies 12 as well, each operating on different wafers.

Fig. 1B illustrates a side cross sectional view of the apparatus 10 taken along line A-A of Fig. 1A according to the present invention. As illustrated, the system 10 is capable of depositing thin metal films onto the wafer.

Each wafer head assembly 16 includes a nonconductive, preferably circular, head assembly 22 with a cavity that is preferably a few millimeters deep at its center and which cavity may contain a resting pad 25. The semiconductor wafer is loaded into this cavity 22, backside first, against the resting pad 25 using a conventional type of transport or vacuum mechanism to ensure that the wafer is stationary with respect to the wafer head assembly while in use. A nonconductive retaining ring 24 at the periphery of the wafer head assembly 10 includes at least one O-ring or other rubber type seal 26 and a spring loaded cathode contact electrode 28, which each push against the face of the wafer and hold the wafer in place at its very edge. A liquid-tight seal is thus obtained so that the cathode contact electrode 28 is kept isolated from the solution within the container 20, as described hereinafter. The entire back side of the wafer which pushes against resting pad 25 and the front surface areas (typically the outer 1-10mm surface of the front surface area) which are under this retaining ring 24 will thus be protected from any and all solutions, including electrolyte, as discussed hereinafter.

The mechanical pad assembly 12 is disposed within container 20, which container 20 holds the various solutions that will be introduced, as described previously and hereinafter. Mechanical pad assembly 12 includes an anode plate 30 that preferably has a thin flat circular shape and is made of a porous or solid conductive material such as copper and/or platinum and is mounted so that it rotates about the second axis 18, and rests upon a table and bearing support as is known. A mechanical pad 32, as is known in the art and used, as example, in chemical mechanical polishing, and preferably one that is made of a nonconductive, porous type material such as polyurethane, is mounted onto the face of the anode plate 30. The mechanical pad 32 preferably has a circular shape, but may be shaped in any other form so long as it can effectively polish the wafer. The electrolyte can be fed to the pad 32 from a reservoir (not shown) located behind the anode plate 32 via a chamber 31, which chamber 31 then feeds

the electrolyte up through the anode plate 30 and pad 32 using the in-channel 34. Alternatively, in-channel 44 can also be used to dispense the electrolyte directly down onto the surface of the pad 32.

The wafer head assembly 16 faces toward the mechanical pad assembly 12, and is pushed down with a controlled force. The wafer head assembly 16 rotates around axis 18 using a conventional motorized spindle 36, whereas the mechanical pad assembly 12 rotates around axis 14 using a conventional motorized spindle 38.

Proper drainage channels 40 provide a safe recycling or disposal of electrolyte. Thus, once the electrolyte is placed onto the pad 32 as described above, it can be drained via the drainage channels 40 to a resuscitating reservoir, also not shown, that can replenish and clean the electrolyte, thereby allowing re-use and being environmentally safe.

The inlet 44 can also be used to apply deionized water when operating in the second mode of the invention, as discussed hereinafter.

In operation according to the first mode of the invention, the apparatus 10 applies, using a power source, a negative potential to the cathode contact 28 and a positive potential to the anode 30. The electrolytic solution is introduced through one or both of the in-channels 34 and 44 to the surface of the mechanical polishing pad 32. When an electric current is established between the two electrodes, molecules of metals in electrolyte are ionized and deposited on the surface of the wafer, being attracted thereto by the cathode contact 28. While this is taking place, there is also performed a mechanical polishing using the mechanical pad assembly 12. This mechanical pad assembly 12 substantially prevents molecules of metals from becoming permanently deposited on surfaces of the wafer where such a deposit is undesired, due to the polishing or rubbing action of the mechanical pad 32. Thus, the contaminants or additives referred to above that are presently used to prevent or reduce such depositing are not needed, or alternatively, can be used in much smaller percentages. Accordingly, at the conclusion of the first mode of operation, metal is deposited in vias and the like where desired, and is substantially prevented from being deposited in undesired areas.

In a second mode of operation, a number of different conventional operations can be performed, depending upon the chemicals introduced via the in-channel 44. If chemical mechanical polishing is desired, a slurry can be introduced, although this specific mode of operation is not preferred since it increases the amount of impurities introduced into the apparatus fluid chamber substantially. In the preferred second mode of operation, the apparatus 10 can be used to buff polish the seed layer or be used as an Electro-polisher by reversing the current polarity (cathode and anode polarity). Further, the apparatus 10 can also be purged with M water if it is necessary to leave the wafer clean but wet with deionized water, and polishing using the mechanical pad 32 with the deionized water can take place. Thereafter, after lifting the wafer off the pad 32, spin drying of the wafer on the rotating wafer head assembly 12 can take place.

Fig. 2 illustrates another embodiment of the invention. Like reference numerals are used to indicate structure that corresponds to that of Figs. 1A and 1B described above. In this embodiment of the invention, the wafer is stationery, and electrochemical mechanical deposition apparatus 100 is disposed within a container (not shown) that collects spent solutions. The electrochemical mechanical deposition apparatus 100 corresponds in structure in large part to the wafer head assembly 16 previously described with reference to Fig. 1B. In this embodiment, however, the electrochemical mechanical deposition apparatus 100 includes a mechanical pad 32, which is rotated by the spindle shaft 36. Spindle shaft 36 is illustrated as being rotated and moved side to side and held in proper position using DC motor 102, weights 104, bearing sets 106 and 108 and springs 110, all of which are conventional.

The electrolyte solution is introduced using in passage 34, and it flows to the desired surface of the wafer through the porous anode 30 and mechanical pad 32. It is expelled through out-channel 40.

Operation of the Fig. 2 embodiment is very similar to that of the first mode described with respect to Figs. 1A and 1B. Specifically, deposition of a conductive material using an electrolyte, such as described previously, in desired vias and/or other areas, is obtained at the same time that mechanical polishing of the surface of the wafer using rotating pad 32, which may be the shape of a rectangle, a circle, or a pie or the like, takes place.

The electrochemical mechanical deposition apparatus according to the present embodiment also reduces the need for pulse generating power supplies because the mechanical pulsing that is generated from the movement of the pad creates sufficient pulsing. This mechanical pulsing is created as a result of the wafer being in contact with the pad as it is moved in relation to the wafer. The benefit of the mechanical pulsing is that it improves grain size and copper film integrity without the need for power supplies with pulsing capabilities.

Figs. 4A-4C illustrate yet another preferred embodiment of the present invention. Like reference numerals are used to indicate structure that corresponds to that of Figs. 1A, 1B, and 2 described above. In this embodiment of the invention, the electrochemical mechanical deposition apparatus 200 contains a mechanical pad assembly 210 that corresponds to the mechanical pad assembly 12 and a wafer head assembly 240 that corresponds to the wafer head assembly 16. In this embodiment, the electrochemical mechanical deposition apparatus 200 includes a circular or square mechanical pad 212 mounted on a cylindrical anode 214 that rotates about a first axis 216 as illustrated in Figs. 4A and 4C, whereas the wafer rotates about a second axis 242 as illustrated in Fig. 4B.

The mechanical pad 212 can have a size that either polishes the entire useable portion of the wafer, or only a section of the wafer at any given time. If only a portion of the wafer is polished at any given time, a drive assembly (not shown) must also be included in order to move the anode 214, and thereby the mechanical pad 212, so that it is in contact with the portion of the wafer that needs to be acted upon at that moment in time.

In operation, it will be appreciated that the belt-shaped mechanical pad 212 polishes the wafer similar to the manner in which a roller paintbrush paints a wall. While operating, the electrolyte or other solution is introduced to the mechanical pad 212 from a reservoir (not shown) located in proximity to the anode 214. In one specific embodiment, the anode 214 contains an in-channel 224 that includes a passageway 226 within anode 214 and holes 228 that are made in the anode 214, which together provide a path for the solution to be fed to the mechanical pad 212. Alternatively, the electrolyte solution can be dispensed directly onto the pad 212 through a channel 213 in accordance with the methods described earlier herein. The solution will be contained within a non-conductive chamber 230 that is created around the wafer head assembly 240, and a non-conductive solution containment housing 250, which housing contains an out-channel 252. O-rings and other conventional structures, as described earlier herein, to seal the solution within the solution containment housing 250 may be used in this embodiment.

Again, the electrochemical mechanical deposition apparatus according to the present invention reduces the need for pulse generating power supplies because the mechanical pulsing that is generated from the rotating movement of the pad and wafer creates sufficient pulsing.

According to the present invention, in any of the embodiments, since mechanical action is used to prevent undesired build-up of a conductor on undesired areas of a wafer surface, leveling agents are not typically needed, or needed in a much smaller percentage than conventionally used. Further a polished smooth and shiny conductive surface can be obtained.

Although only the above embodiments have been described in detail above, those skilled in the art will readily appreciate that many modifications of the exemplary embodiment are possible without materially departing from the novel teachings and advantages of this invention.

I claim:

1. A method of depositing a conductive material from an electrolyte solution to a portion of a workpiece, the method comprising the steps of:

applying the conductive material to at least the portion of the workpiece using the electrolyte solution disposed on a surface of the workpiece, the workpiece being positioned in proximity to an anode; and

minimizing accumulation of the conductive material to another area different from the portion by polishing the another area while the step of applying the conductive material is being performed.

2. The method according to claim 1, wherein the step of applying the conductive material further comprises the steps of moving a pad that is attached to the anode and contacts the workpiece to assist in retaining the electrolyte solution in contact with the portion of the workpiece and applying a current between the anode and the workpiece so that ionization will occur, thereby resulting in the deposition of the conductive material to the portion.

3. The method according to claim 2, wherein the step of moving the pad also minimizes accumulation of the conductive material to the another area.

4. The method according to claim 2, wherein the step of applying the conductive material further comprises the step of flowing the electrolyte solution through the anode and the pad.

5. The method according to claim 2, wherein the step of applying the conductive material further comprises the step of dispensing the electrolyte solution directly to the pad.

6. The method according to claim 2, wherein the movement of the pad generates mechanical pulsing, thereby improving grain size.

7. The method according to claim 1, further comprising the steps of:
removing the electrolyte solution from a chamber in which the steps of applying and minimizing accumulation take place;

cleaning the removed electrolyte solution; and
replenishing the electrolyte solution for application back into the chamber to the workpiece.

8. The method according to claim 1, wherein the step of minimizing accumulation prevents the conductive material from being formed on the another area of the workpiece.

9. The method according to claim 1, wherein the portion of the workpiece comprises a via and the workpiece comprises a wafer.

10. The method according to claim 1, wherein the portion of the workpiece is below a top surface of the workpiece and the another area different from the portion is the top surface of the workpiece.

11. A method of depositing a conductive material from an electrolyte solution on a wafer, the method comprising the steps of:

applying a potential difference between the wafer and an anode having a pad attached thereto, the wafer being positioned in proximity to the anode, thereby causing the application of the conductive

5 material to at least a portion of the wafer; and

minimizing accumulation of the conductive material to another area of the wafer different from the portion by polishing the another area with the pad while the step of applying the conductive material is being performed.

12. The method according to claim 11, wherein the conductive material comprises copper.

10 13. The method according to claim 11, wherein the portion of the wafer is below a top surface of the wafer and the another area of the wafer different from the portion is the top surface of the wafer.

14. The method according to claim 11, wherein the step of applying the conductive material further comprises the step of moving the pad that is attached to the anode and contacts the wafer to assist in retaining the electrolyte solution in contact with the portion of the wafer.

15 15. The method according to claim 14, wherein the step of moving the pad also minimizes accumulation of the conductive material to the another area.

16. The method according to claim 14, wherein the step of moving the pad also generates mechanical pulsing, thereby improving grain size.

17. The method according to claim 11, wherein the step of applying the conductive material
20 further comprises the step of flowing the electrolyte solution through the anode and the pad.

18. The method according to claim 11, wherein the step of applying the conductive material further comprises the step of dispensing the electrolyte solution directly to the pad.

19. The method according to claim 11, wherein the step of minimizing accumulation prevents the conductive material from being formed on the another area of the wafer.

25 20. The method according to claim 11, wherein the step of applying, the potential difference applies the potential difference having a first polarity, and further including the following steps prior to the step of applying:

applying a second potential difference having a second polarity opposite the first polarity between the wafer and the anode having the pad attached thereto; and

30 polishing the wafer while applying the second potential difference.

21. A method of transferring an electrolyte solution containing a conductive material to a workpiece surface so that depositing of the conductive material can occur upon application of power, the method comprising the steps of:

placing a pad in contact with the workpiece surface; and

applying the electrolyte solution so that the electrolyte solution is held within the pad and in contact with the workpiece surface, thereby providing a condition suitable for depositing of the conductive material upon application of power.

22. The method according to claim 21, wherein during the step of applying the electrolyte solution, the conductive material is deposited below a top surface of the workpiece and is inhibited from being deposited on the top surface of the workpiece by moving the pad on the top surface of the workpiece.

23. The method according to claim 21, wherein the step of applying the electrolyte solution further includes the step of applying a potential difference between the workpiece and an anode having the pad attached thereto.

24. An apparatus for depositing a conductive material from an electrolyte solution upon application of power to at least a portion of a workpiece and minimizing accumulation of the conductive material to another area different from the portion of the workpiece, the apparatus comprising:

an anode capable of receiving a first potential upon application of power, the anode spaced from the workpiece that is capable of receiving a second potential opposite the first potential upon application of power;

a movable pad attached to the anode and positioned between the anode and the workpiece, wherein movement of the pad relative to the workpiece minimizes accumulation of the conductive material to the another area when the pad is making contact with the another area of the workpiece; and a chamber that allows the electrolyte solution to be disposed on the workpiece and the conductive material to be deposited on the portion of the workpiece.

25. The apparatus according to claim 24, wherein a plurality of pads are attached to the anode and positioned between the anode and the workpiece, wherein the plurality of pads minimize accumulation of the conductive material to the another area when the plurality of pads are making contact with the another area of the workpiece.

26. The apparatus according to claim 24, wherein the workpiece rotates about one axis and the pad rotates about the same one axis.

27. The apparatus according to claim 24, wherein the workpiece rotates about one axis and the pad rotates about a second axis different from the first axis.

28. The apparatus according to claim 24, wherein the pad is shaped as a cylinder.

29. The apparatus according to claim 24, wherein the pad is shaped around the anode that is shaped as a cylinder.

30. The apparatus according to claim 29, wherein the electrolyte solution is flowed from an in-channel directly to the pad.

31. The apparatus according to claim 24, further comprising:
a workpiece head assembly adapted to support the workpiece and adapted to rotate the workpiece about a first axis; and
a pad assembly including the pad and the anode, the pad being movable with respect to the workpiece to assist in retaining the electrolyte solution in contact with the portion of the workpiece.
32. The apparatus according to claim 31, wherein the workpiece head assembly includes a resting pad and a retaining ring adapted to sustain the workpiece during the rotation of the workpiece.
33. The apparatus according to claim 24, wherein the chamber comprises:
an in-channel for flowing the electrolyte solution to the workpiece; and
an out-channel for flowing out the electrolyte solution from the chamber.
34. The apparatus according to claim 33 further comprising a resuscitating reservoir for replenishing and cleaning the electrolyte solution that is flowing out through the out-channel.
35. The apparatus according to claim 33, wherein the electrolyte solution is flowed from the in-channel through the anode and the pad to the workpiece.
36. The apparatus according to claim 33, wherein the electrolyte solution is flowed from the in-channel directly to the pad to the workpiece.
37. The apparatus according to claim 24, further comprising:
a workpiece head assembly adapted to support the workpiece, the workpiece being stationary;
a pad assembly having the pad attached to the anode; and
a shaft connected to the anode, the shaft adapted to rotate about a first axis, thereby causing the anode and the pad to rotate about the first axis.
38. The apparatus according to claim 24, further comprising:
a workpiece head assembly adapted to support the workpiece, the workpiece being adapted to rotate about a first axis;
a pad assembly having the pad attached to the anode, the anode being cylindrical and adapted to rotate about a second axis.
39. The apparatus according to claim 38, wherein the cylindrical anode includes a passageway and a plurality of holes, wherein the electrolyte solution is flowed to the workpiece through the passageway and the plurality of holes via the pad.
40. The apparatus according to claim 38, wherein the electrolyte solution is flowed from an in-channel directly to the pad.
41. An apparatus for simultaneously depositing a conductive material from an electrolyte solution to a portion of a workpiece and minimizing accumulation of the conductive material to another area of the workpiece, the apparatus comprising:

an anode capable of receiving a first potential upon application of power, the anode spaced from the workpiece that is capable of receiving a second potential opposite the first potential upon application of power;

5 a pad positioned between the anode and the workpiece, the pad being in movable contact the workpiece and inhibiting application of the conductive material to another area of the workpiece when power is being supplied to the anode and the workpiece, the pad retaining and feeding the electrolyte solution in contact with the portion of the workpiece; and

a chamber that allows the electrolyte solution to be disposed on a surface of the workpiece and the conductive material to be formed on the portion of the workpiece.

10 42. The apparatus according to claim 41 further including:
a pad assembly having the pad attached to the anode; and
a workpiece head assembly adapted to support the workpiece.

43. The apparatus according to claim 41, wherein the workpiece comprises a wafer.

15 44. A method of depositing a conductive material from an electrolyte solution to a workpiece, the method comprising the steps of:

applying the conductive material to at least a first portion of an exposed surface of the workpiece using the electrolyte solution disposed on the exposed surface of the workpiece, the workpiece being positioned in proximity to an anode; and

20 minimizing accumulation of the conductive material to a second portion of the exposed surface by reducing electrolyte solution contact to the second portion of the exposed surface.

45. The method according to claim 44, wherein the step of minimizing accumulation is performed with a pad that is in contact with and polishes the second portion of the exposed surface while the step of applying the conductive material to the first portion of the exposed surface is being performed.

25 46. The method according to claim 45, wherein the step of applying the conductive material further comprises the step of flowing the electrolyte solution through the anode and the pad.

47. The method according to claim 45, wherein the step of applying the conductive material further comprises the step of dispensing the electrolyte solution directly to the pad.

30 48. The method according to claim 44, wherein the second portion of the exposed surface is a top surface of the workpiece and the first portion of the exposed surface of the workpiece to which the conductive material is applied is below the top surface of the workpiece.

49. The method according to claim 44, wherein the step of applying the conductive material further includes the step of applying a potential difference between the workpiece and the anode.

35 50. A method of depositing a conductive material from an electrolyte solution on a wafer, the method comprising the steps of:

applying a second potential difference having a first polarity between the wafer and an anode having a pad attached thereto;

polishing the wafer while applying the second potential difference;

applying a first potential difference having a second polarity opposite the first polarity
5 between the wafer and the anode having the pad attached thereto, the wafer being positioned in proximity to the anode, thereby causing the application of the conductive material to at least a portion of the wafer; and

minimizing accumulation of the conductive material to another area of the wafer different from the portion by polishing the another area with the pad while the step of applying the conductive
10 material is being performed.

51. The method according to claim 50, wherein the another area is a top surface of the wafer and the portion of the wafer to which the conductive material is applied is below the top surface of the wafer.

52. The method according to claim 50, wherein the step of applying the conductive material
15 further comprises the step of flowing the electrolyte solution through the anode and the pad.

53. The method according to claim 50, wherein the step of applying the conductive material further comprises the step of dispensing the electrolyte solution directly to the pad.

54. A method of depositing a conductive material from an electrolyte solution to a workpiece, the method comprising the steps of:

20 applying the conductive material to the workpiece using the electrolyte solution disposed on a surface of the workpiece, the workpiece being positioned in proximity to an anode; and
polishing the workpiece while the step of applying the conductive material is being performed.

55. The method according to claim 54, wherein the step of applying the conductive material
25 further comprises the steps of moving a pad that is attached to the anode and contacts the workpiece to assist in retaining the electrolyte solution in contact with the workpiece and applying a current between the anode and the workpiece so that ionization will occur, thereby resulting in the deposition of the conductive material to the workpiece.

56. The method according to claim 55, wherein the step of moving the pad also polishes the
30 workpiece.

57. The method according to claim 55, wherein the step of applying the conductive material further comprises the step of flowing the electrolyte solution through the anode and the pad.

58. The method according to claim 55, wherein the step of applying the conductive material further comprises the step of dispensing the electrolyte solution directly to the pad.

59. The method according to claim 55, wherein the movement of the pad generates mechanical pulsing, thereby improving grain size.

60. The method according to claim 54, further comprising the steps of:
removing the electrolyte solution from a chamber in which the steps of applying and
5 polishing take place;
cleaning the removed electrolyte solution; and
replenishing the electrolyte solution for application back into the chamber to the
workpiece.

61. The method according to claim 54, wherein the conductive material comprises copper.

10 62. The method according to claim 54, wherein the workpiece comprises a wafer.

63. The method according to claim 54 further comprising the steps of applying a slurry to the workpiece and chemically mechanically polishing the workpiece.

64. The method according to claim 1 further comprising the steps of applying a slurry to the workpiece and chemically mechanically polishing the workpiece.

15 65. The method according to claim 11 further comprising the steps of applying a slurry to the workpiece and chemically mechanically polishing the workpiece.

1/5

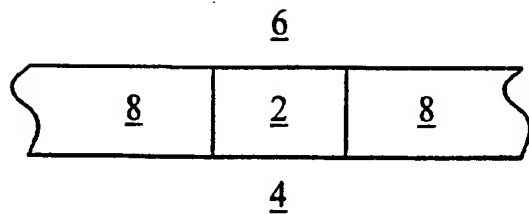


FIG. 3

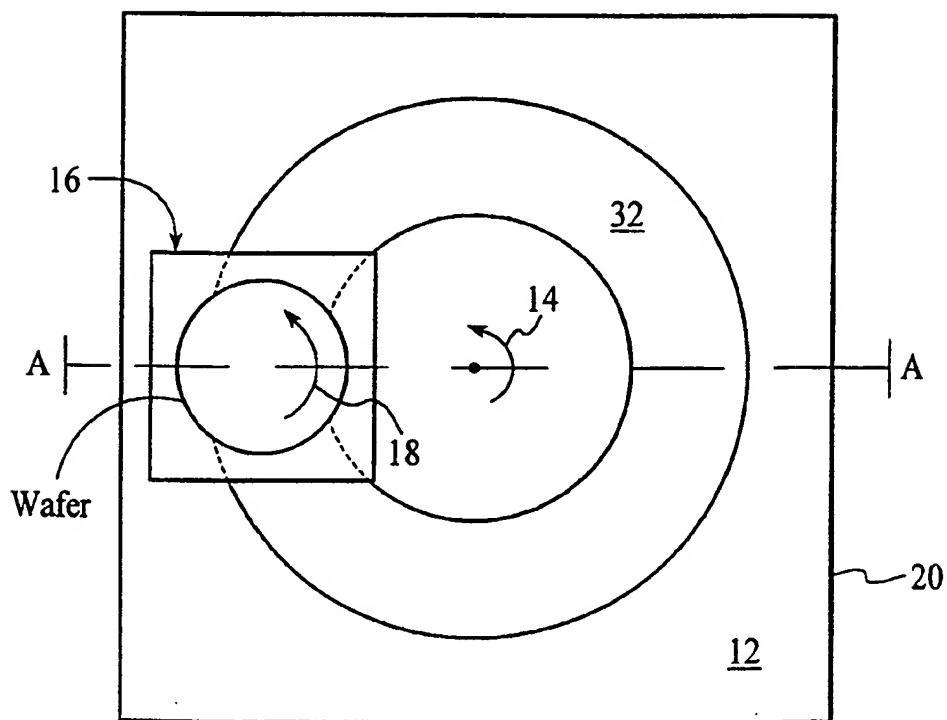


FIG. 1A

2/5

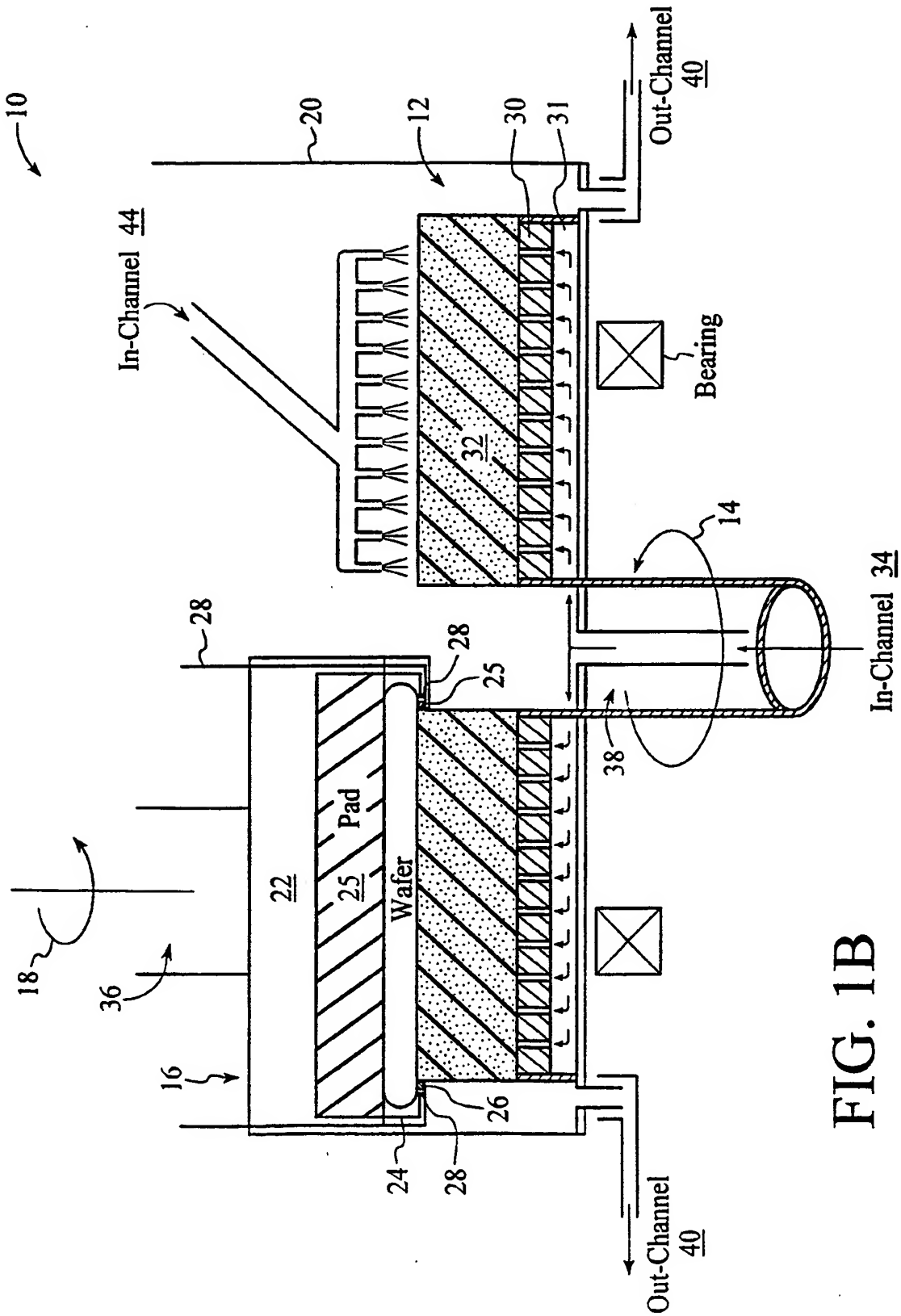


FIG. 1B

3/5

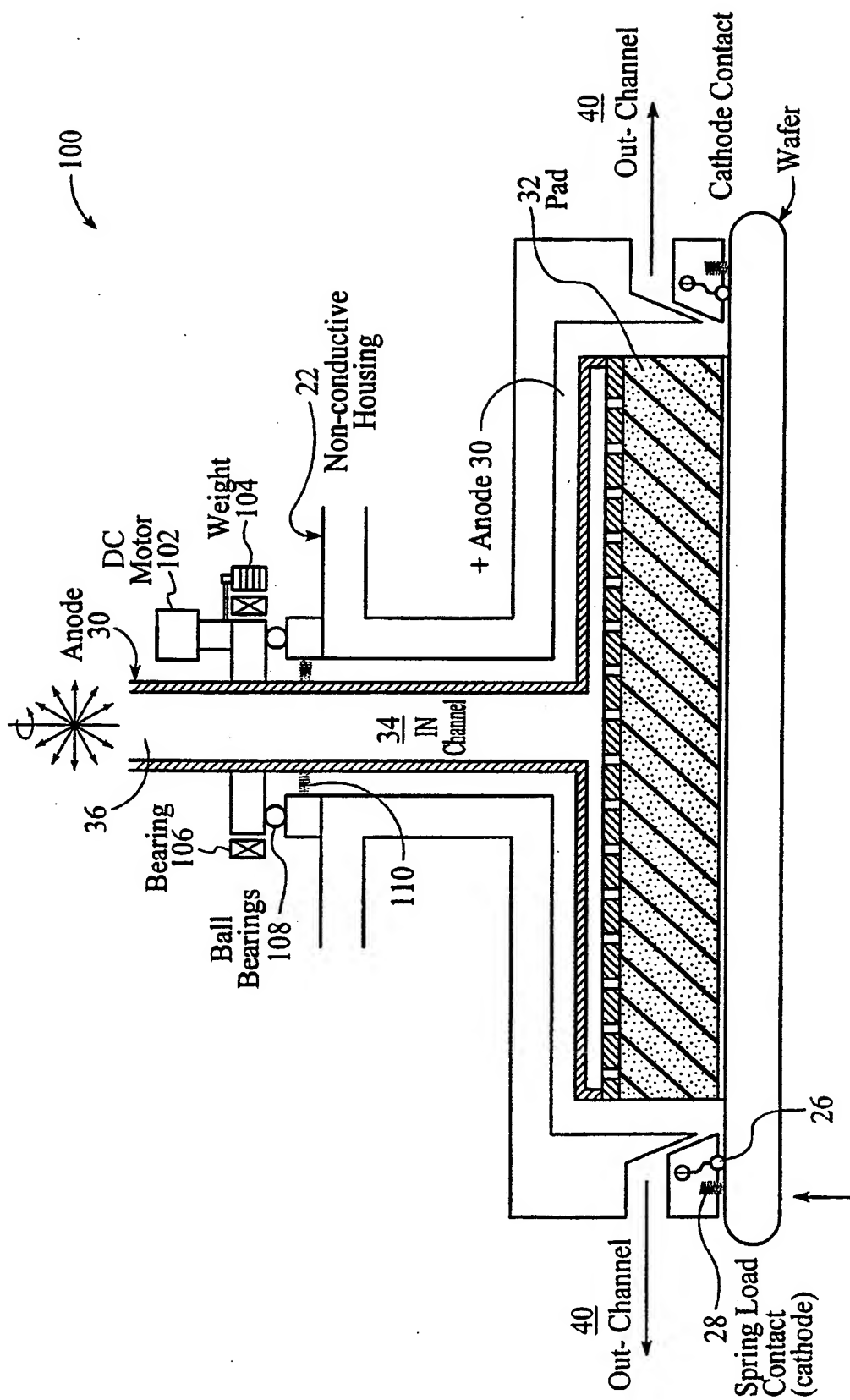


FIG. 2

4/5

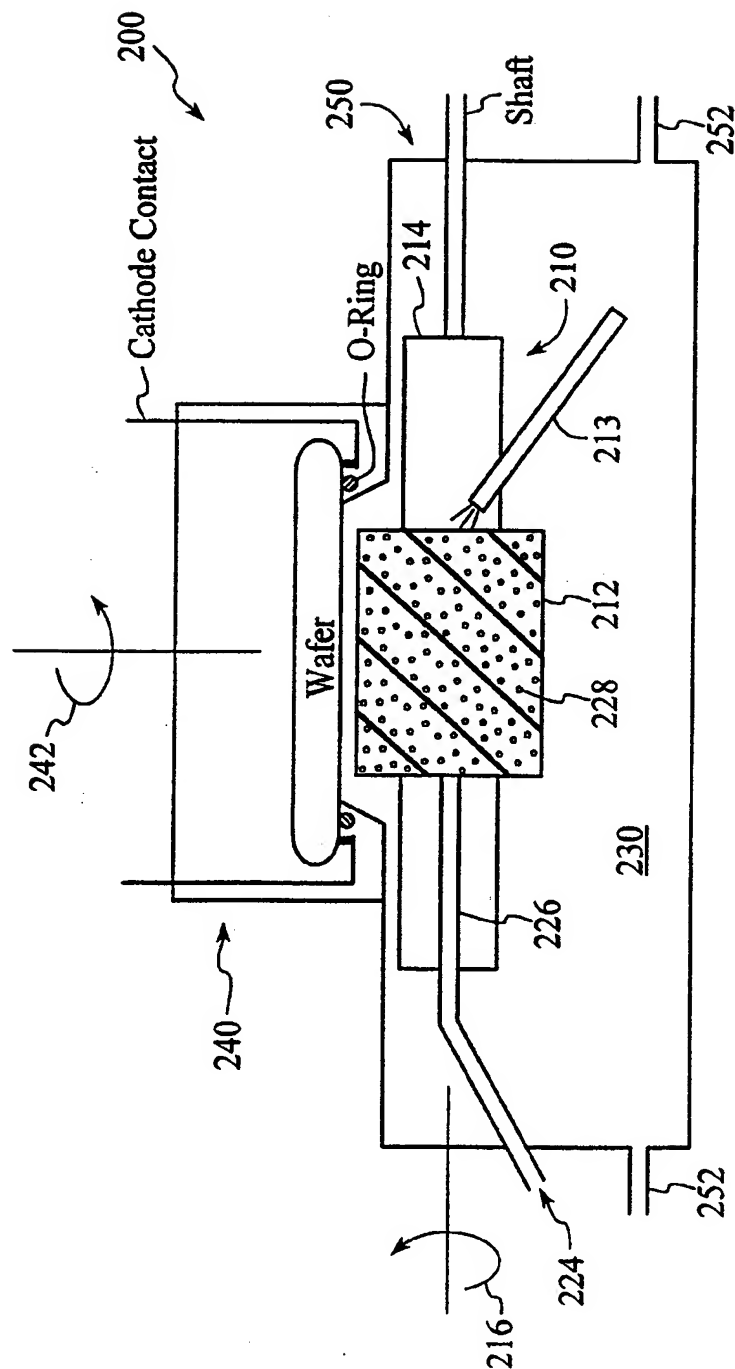


FIG. 4A

5/5

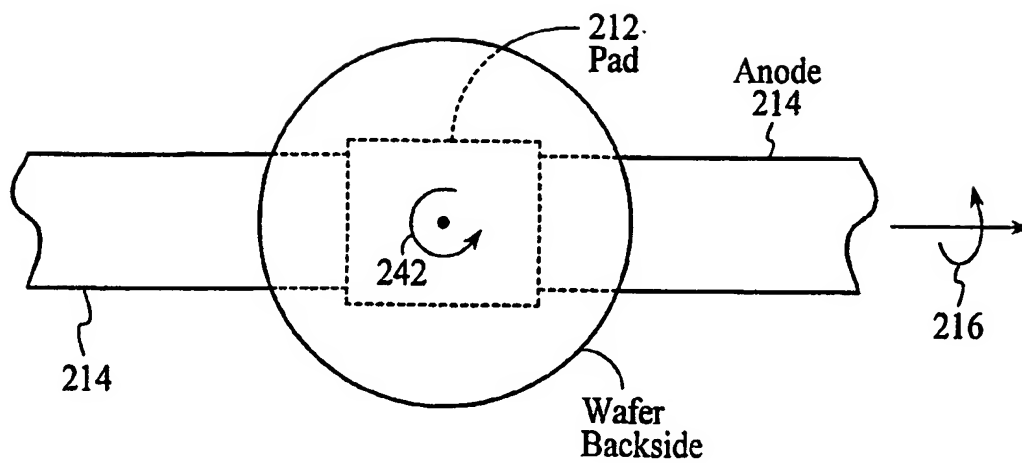


FIG. 4B

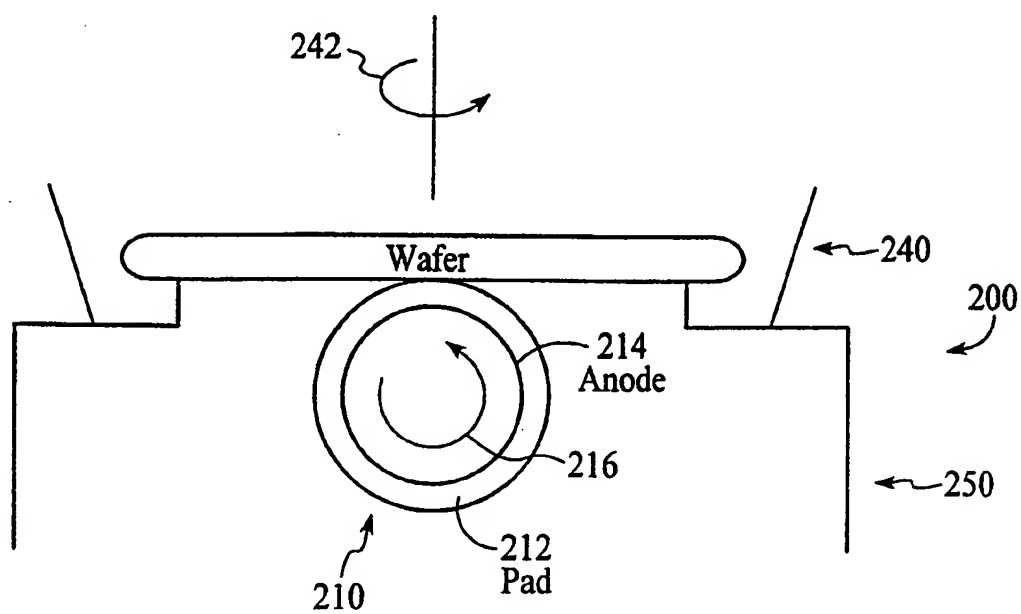


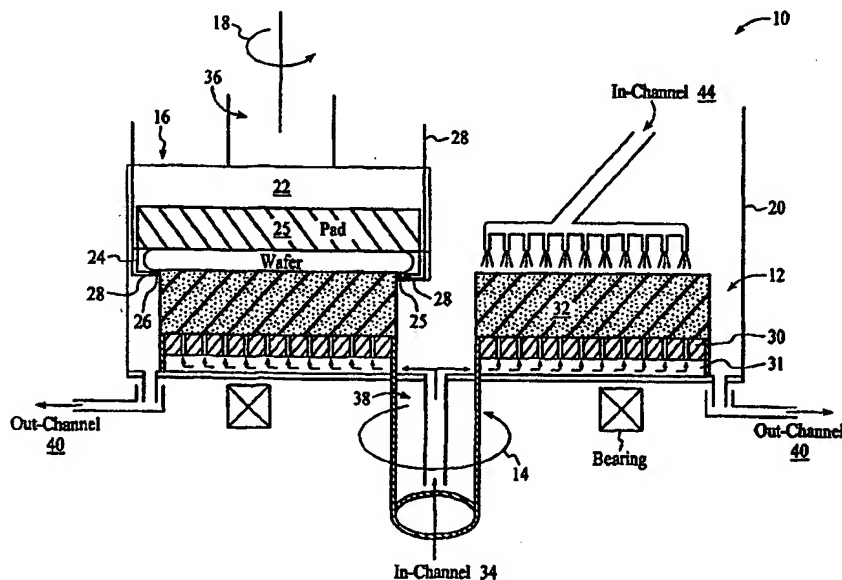
FIG. 4C



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : C25D 5/02, 5/22, 5/06	A3	(11) International Publication Number: WO 00/26443 (43) International Publication Date: 11 May 2000 (11.05.00)
(21) International Application Number: PCT/US99/25656 (22) International Filing Date: 2 November 1999 (02.11.99) (30) Priority Data: 60/106,853 3 November 1998 (03.11.98) US 09/201,929 1 December 1998 (01.12.98) US (71) Applicant: NUTOOL, INC. [US/US]; 1645 McCandless Drive, Milpitas, CA 95035 (US). (72) Inventor: TALIEH, Homayoun; 2211 Bentley Ridge Drive, San Jose, CA 95138 (US). (74) Agents: JAKOPIN, David, A. et al.; Pillsbury Madison & Sutro LLP, 1100 New York Avenue N.W., Washington, DC 20005 (US).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> (88) Date of publication of the international search report: 12 October 2000 (12.10.00)

(54) Title: METHOD AND APPARATUS FOR ELECTROCHEMICAL MECHANICAL DEPOSITION

**(57) Abstract**

The present invention deposits a conductive material from an electrolyte solution to a predetermined area of a wafer. The steps that are used when making this application include applying the conductive material to the predetermined area of the wafer using an electrolyte solution disposed on a surface of the wafer, when the wafer is disposed between a cathode and an anode, and preventing accumulation of the conductive material to areas other than the predetermined area by mechanically polishing the other areas while the conductive material is being applied.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/25656

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C25D5/02 C25D5/22 C25D5/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C25D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	<p>US 6 004 880 A (LIU YAUH-CHING ET AL) 21 December 1999 (1999-12-21)</p> <p>column 3, line 61 - line 64 column 4, line 53 - line 67 column 5, line 63 - column 6, line 14 claims 1,3-5,12,14</p> <p>---</p> <p>-/--</p>	<p>1-3, 8-15, 18, 19, 21-24, 41-45, 47-51, 53-56, 58,61-65</p>

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

21 June 2000

Date of mailing of the international search report

06/07/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Zech, N

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/25656

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT.

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 20 08 664 A (LICENTIA GMBH) 9 September 1971 (1971-09-09) page 3, line 11 - line 18 examples claims 1-4 figure 1	1-3, 5, 8, 10, 21-24, 41, 44, 45, 47, 48, 54-56, 58, 61, 63, 64
X	US 5 024 735 A (KADIJA IGOR V) 18 June 1991 (1991-06-18) abstract figures 1, 5, 6 column 5, line 65 - column 6, line 22 column 6, line 47, 48	21, 23, 44, 48, 49
X	M. RUBINSTEIN: "Tampongalvanisieren in der Praxis. Teil 1." GALVANOTECHNIK, vol. 79, no. 10, 1988, pages 3263-3270, XP002140676 Saulgau (Württ.), Germany page 3264, paragraph 3 - paragraph 4 figure 2	21, 23, 41
X	US 4 610 772 A (PALNIK KARL) 9 September 1986 (1986-09-09) abstract column 1, line 62 - line 65 figure 1 claim 1	21, 23, 24, 27-29
A		16
X	US 3 959 089 A (WATTS JOHN D) 25 May 1976 (1976-05-25) abstract column 2, paragraphs 2, 3 column 5, paragraph 2 column 8, paragraphs 4, 7	21
A		1, 11, 24, 41, 44, 50, 54

	-/--	

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/25656

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>DE 43 24 330 A (ATOTECH DEUTSCHLAND GMBH) 3 February 1994 (1994-02-03)</p> <p>abstract column 2, line 37 - line 60 column 4, line 16 - line 24 claims 1,2 figure 1</p> <p>-----</p>	<p>1,8, 10-15, 50,51, 54,61,62</p>

INTERNATIONAL SEARCH REPORT
information on patent family members

International Application No
PCT/US 99/25656

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 6004880	A	21-12-1999	NONE	
DE 2008664	A	09-09-1971	NONE	
US 5024735	A	18-06-1991	AT 183250 T DE 69033245 D DE 69033245 T EP 0458863 A WO 9009469 A US 5114558 A US 5167747 A	15-08-1999 16-09-1999 16-03-2000 04-12-1991 23-08-1990 19-05-1992 01-12-1992
US 4610772	A	09-09-1986	EP 0210072 A	28-01-1987
US 3959089	A	25-05-1976	US 3871983 A	18-03-1975
DE 4324330	A	03-02-1994	AT 143422 T CA 2141604 A WO 9403655 A DE 59303994 D EP 0652982 A ES 2093524 T HK 38697 A JP 7509539 T SG 46609 A	15-10-1996 17-02-1994 17-02-1994 31-10-1996 17-05-1995 16-12-1996 04-04-1997 19-10-1995 20-02-1998